Suturing a tear of the anterior capsulorhexis

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SCIENTIFIC REPORT

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Aim: To describe a new technique of suturing a tear in the anterior capsulorhexis.

Methods: Continuous curvilinear capsulorhexis (CCC) with lens removal was done in five fresh cadaver eyes. The diameter of the CCC was measured with a calliper. Using the same calliper a tear of the CCC was created while opening the calliper's arms. The distance between the calliper's arms needed to tear the CCC was documented. Using 9-0 Ethilon 9011, CS 160-6 sutures in two eyes, 9-0 Prolene, D-8229, CTC-6L sutures in two eyes, and 10-0 Prolene, 9090, CTC-6 suture in one eye, the tears were sutured. A tear in the CCC was created again in the same way as the first tear. The distance between the calliper's arms needed to tear the CCC was documented again.

Results: Suturing of the tear restored some of the strength/elasticity of the CCC. Better results were found while using the 9-0 Prolene, D-8229, CTC-6L sutures than with the two others sutures.

Conclusions: Suturing of a broken CCC can restore at least some of the strength/elasticity of the CCC. This can be important before intraocular lens (IOL) implantation for the safety of the implantation or after the implantation to ensure proper fixation of the IOL.

Tear of the continuous curvilinear capsulorhexis (CCC) can complicate the implantation of the intraocular lens (IOL) and jeopardise its fixation in the capsular bag. The proper fixation of the lens in the capsular bag has always been crucial for the success of the IOL function and is more important today as many new specialised IOLs (that is, multifocal and accommodative IOLs) are being introduced. For these IOLs to function optimally, proper fixation and centration in the capsular bag is required.

In this study we present a new technique to preserve a torn CCC by suturing the tear.

METHODS

Five fresh cadaver eyes (within 72 hours post mortem) were used in this study. The eyes were prepared according to the modified Miyake-Apple technique.[1 2] The cornea and iris were removed and a CCC was created. The crystalline lens was evacuated with phacoemulsification using the endocapsular technique. The capsular bag was filled with ophthalmic viscoelastic device (OVD) (Hyalon, AMO, Santa Ana, CA, USA) and the diameter of the CCC was measured with a calliper (Manostat, Switzerland) (fig 1). The external arms of the same calliper were inserted into the CCC and slowly opened until a tear of the CCC occurred and the distance between the arms was recorded (fig 2). Using 9-0 Ethilon 9011, CS 160-6 sutures (Ethicon, Inc, Somerville, NJ, USA) in two eyes, 9-0 Prolene, D-8229, CTC-6L sutures (Ethicon) in two eyes and 10-0 Prolene, 9090, CTC-6 suture (Ethicon) in one eye, the tears were sutured (fig 3). The capsular bag was filled again with the same OVD and the diameter of the new CCC was measured. The external arms of the calliper were inserted again into the CCC to create a tear in the same way as the first tear (fig 4). The distance between the external arms of the calliper was documented.

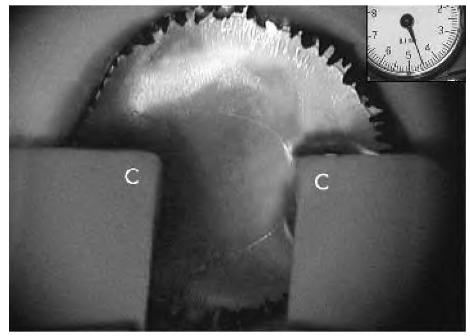

Figure 1 The diameter of the CCC was measured with callipers before creation of the tear.

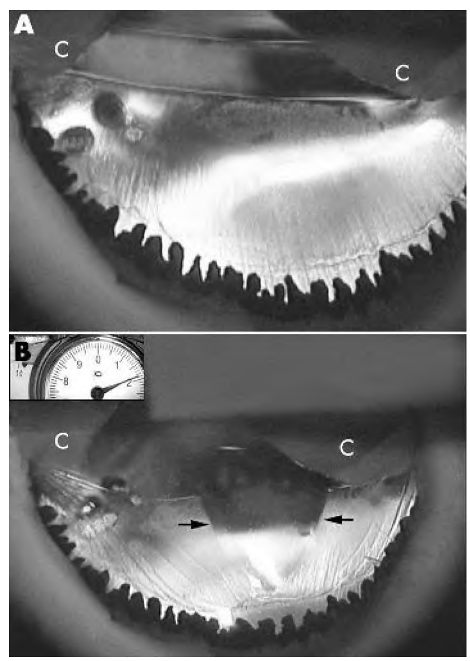

Figure 2 The tear of the anterior CCC was created by a slow opening of the calliper's external arms. (A) Stretching of the CCC. (B) A tear was created (arrow). The distance between the calliper's external arms was documented.

Abbreviations: CCC, continuous curvilinear capsulorhexis; IOL, intraocular lens; OVD, ophthalmic viscoelastic device

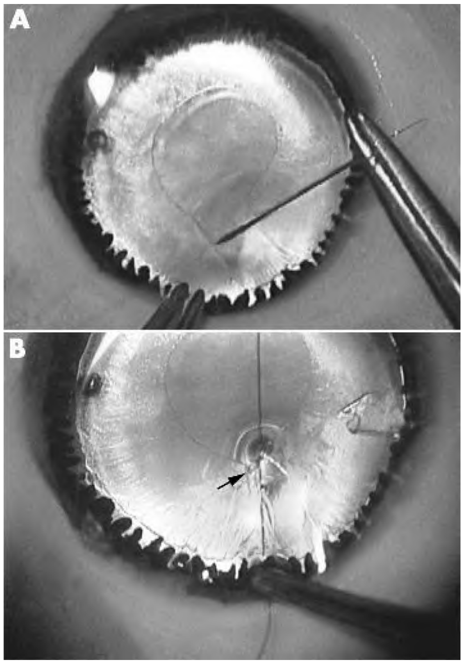

Figure 3 Suturing the tear. (A) Placing the suture through the broken capsule. (B) Tying the suture. Notice that a small loop was left (arrow).

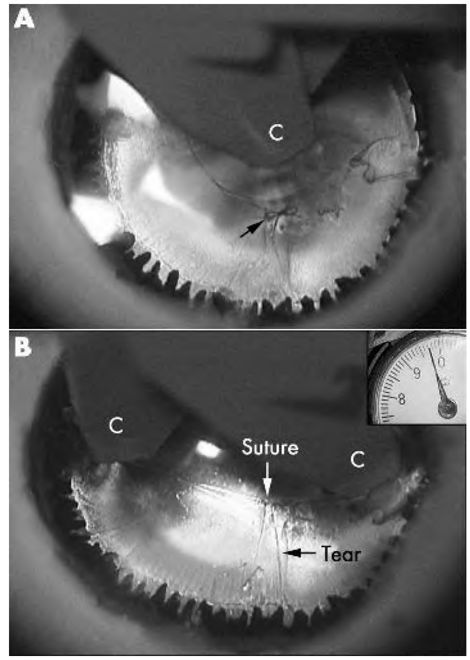

Figure 4 Tearing the sutured CCC. (A) Insertion of the calliper's external arms into the sutured CCC (the arrow indicate the suture). (B) Stretching the CCC. Notice that the suture is holding when pressure is being applied to the CCC.

Calculation of the strength/elasticity of the sutured CCC

We used two formulas to calculate the strength/elasticity of the sutured CCC:

(1) Comparing the actual tear length to the calculated tear length

With the tear length of the original CCC (tear length = the distance between the calliper's external arms needed to tear the CCC) the expected tear length of the new diameter of the CCC after suturing was calculated. The expected stretch length was calculated by subtracting the CCC diameter after suturing from the expected tear length. The actual stretch length was calculated by subtracting the new CCC diameter after suturing from the actual tear length. The restored strength/elasticity of the CCC was expressed as a percentage of the primary strength by dividing the actual stretch length by the expected stretch length.

(2) Comparing the calculated elasticity values before and after suturing

The elasticity of the CCC was calculated by dividing the calculated circumference of the CCC at the tearing point ($d \times 2+2$; $d =$ the distance between the calliper's external arm needed to tear the CCC doubled by 2 and adding 2 mm for the width of the calliper's arm (1 mm for each side)) by the calculated circumference of the CCC ($D \times \pi$, $D =$ diameter of the CCC).

RESULTS

The cross sectional profile of all suture needles used was typical of a cutting needle and not round like a vascular needle. That caused immediate breaks at the entering sites of the needles in the capsule. We had to take big "bites" and leave a small loop (as opposed to cinching the first throw taught) when tying the sutures to avoid "cheese wiring."

The strength/elasticity of the new sutured CCC was found to range between 37% and 99% of the original strength/elasticity according to the first formula (table 1), and 5% and 99% according to the second formula (table 2). The strength of the new sutured CCC was found to be better when the 9-0 Prolene, D-8229, CTC-6L sutures were used in both formulas (cases 3 and 5: 70% and 99% according to the first formula; 62% and 99% according to the second formula) compared to the other two sutures (cases 1, 2, and 4 around 40% according to the first formula; ranging between 5% and 48% according to the second formula).

DISCUSSION

In this study we found that suturing a tear in the CCC is possible and can restore some of the strength/elasticity of the CCC. Intact CCC enables safer implantation of the IOL and is important for proper fixation and centration of the IOL in the capsular bag. Centration is especially imperative for proper function and prevention of adverse effects when using the modern multifocal and accommodative IOLs. The suturing can take place before or after the IOL implantation.

Nishi described successful suturing of the capsule in rabbits eyes after evacuation of the lens and implantation of a silicone balloon lens into the capsular bag,[3] but he did not succeed in repeating it in human cadaver eyes (personal communication, August 2005).

Owing to the small sample size that we had in each group it is difficult to conclude which suture/needle was the best. Better results were found with the 9-0 Prolene, D-8229, CTC-6L sutures than the 9-0 Ethilon 9011, CS 160-6 sutures and 10-0 Prolene, 9090, CTC-6 suture. We hypothesise that this is mainly related to the cross sectional shape of the 9-0 Ethilon 9011, CS 160-6 needle, which has fewer sharp edges from the other two. This needle, owing to its rounder profile, caused fewer radial tears of the capsule with a rounder hole that was more stable and had less of a tendency to break. Another possible explanation can be our learning curve, since we used this suture later on in the study. As to the suture size, the 9-0 seems to act better than the 10-0 which is too fine and can cut the capsule. Regarding the technique, we found that

Table 1 Percentage of sutured CCC strength/elasticity from the original CCC strength/elasticity (formula 1)

Case	Suture used	Primary CCC diameter (mm)	Tear length of primary CCC (mm)	CCC diameter after suturing (mm)	Expected tear length of new CCC (mm)	Actual tear length of new CCC (mm)	Expected stretch length of new CCC (mm)	Actual stretch length of new CCC (mm)	% of strength of new CCC from original CCC
1	9-0 Ethilon 9011, CS 160-6	4.1	8.7	5.1	10.8	7.2	10.8–5.1 = **5.7**	7.2–5.1 = **2.1**	**36.8**
2	9-0 Ethilon 9011, CS 160-6	5	14.2	5.3	15.1	9	15.1–5.3 = **9.8**	9–5.3 = **3.7**	**37.8**
3	9-0 Prolene, D-8229, CTC-6L	4.5	11.9	4.5	11.9	9.7	11.9–4.5 = **7.4**	9.7–4.5 = **5.2**	**70**
4	10-0 Prolene, 9090, CTC-6	6.2	14	6	13.5	9.3	13.5–6 = **7.5**	9.3–6.0 = **3.3**	**44**
5	9-0 Prolene, D-8229, CTC-6L	4.5	10.7	5.2	12.4	12.3	12.7–5.2 = **7.2**	12.3–5.2 = **7.1**	**98.6**

Table 2 Percentage of sutured CCC strength/elasticity from the original CCC strength/elasticity (formula 2)

Case	Suture used	Primary CCC diameter (mm)	Primary CCC circumference (mm)	Tear length primary CCC (mm)	Circumference at tearing point, primary CCC (mm)	Primary CCC elasticity (%)	CCC diameter after suturing (mm)	CCC circumference after suturing (mm)	Tear length of sutured CCC (mm)	Circumference at tearing point sutured CCC (mm)	Sutured CCC elasticity (%)	% of elasticity of the sutured CCC from the primary CCC (%)
1	9-0 Ethilon 9011, CS 160-6	4.1	12.87	8.7	19.4	50.6	5.1	16	7.2	16.4	2.5	**5**
2	9-0 Ethilon 9011, CS 160-6	5	15.7	14.2	30.4	93.6	5.3	15.1	9	20	20.2	**22**
3	9-0 Prolene, D-8229, CTC-6L	4.5	14.13	11.9	25.8	82.6	4.5	11.9	9.7	21.4	51.5	**62**
4	10-0 Prolene, 9090, CTC-6	6.2	19.47	14	30	54.1	6	13.5	9.3	20.6	26.2	**48**
5	9-0 Prolene, D-8229, CTC-6L	4.5	14.13	10.7	23.4	63.6	5.2	12.4	12.3	26.6	62.9	**99**

taking relatively big "bites" of capsule at the sides of the tear and leaving a small loop of the suture, while tying it, are recommended to avoid "cheese wiring." This technique will probably be challenging to perform in living patients through the cornea. The Siepser slipknot technique[4 5] may be the best way to suture the capsules in these cases to minimise the forces applied to the capsule while tying the sutures.

Further investigations are required before applying our findings clinically. We expect that engineering a long, high radius needle with a round cross sectional profile attached to a 9-0 suture would improve the results. A different approach will be to develop a very small, short radius needle that will be placed inside the eye with an intraocular needle holder and tying forceps. This approach will probably be less traumatic and will have greater chances of success.

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